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From: Advanced Sonar Division

To: Scientific Officer
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Subj: Annual Progress Report on "Multiple Scatter Theory of Ocean Sediments II," under Grant No. N00014-95-1-0536, for the period 1 March 1995 to 28 February 1996

Ref: (a) Office of Naval Research Grant No. N00014-95-1-0536, "Multiple Scatter Theory of Ocean Sediments II"

Encl: (1) Annual progress report
(2) Material Inspection and Receiving Report (DD form 250) ASG0338

1. Enclosure (1) is submitted in compliance with Ref. (a) as the annual progress report.

2. Enclosure (2) is forwarded as required by DFARS, Appendix F, Distribution for the Material Inspection and Receiving Report. Please sign and return one copy to the address shown above, marked for the attention of the Contracts Office. A signed DD Form 250 is necessary for Applied Research Laboratories, The University of Texas at Austin (ARL:UT) to maintain complete documentation files on the delivery of contractually required items.

Nick Chotiros
Nicholas P. Chotiros

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Annual Progress Report
Grant No. N00014-95-1-0536
1 March 1995 - 28 February 1996

Title : Multiple Scatter Theory of Ocean Sediments II

Principal Investigators: Dr. Nicholas P. Chotiros

Category: Bottom scattering

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Long-term goals:

To develop a new model of acoustic bottom backscatter from sandy sediments, based on a multiple scattering theory approach, and hence, properly explain observed phenomena, including Lambert's rule and frequency dependence of backscattering strength, particularly at shallow grazing angles, for which current theories are at a loss.

Scientific or technological (S&T) objectives:

The underlying idea is based on the fact that real sediments are granular. The hypothesis to be proved is that physical mechanisms for both attenuation and scattering may be found in the interaction of acoustic waves with the granular structure.

Accomplishments:

The effects of granularity have been added to a Biot model of ocean sediments in a numerical simulation by introducing homogeneous layers of random thicknesses on the order of a grain diameter, in which the mean porosity is preserved. Within each layer, conservation of grain volume dictates a linear relationship between the layer thickness, porosity, and grain diameter.

Lateral variations in sediment structure were simulated by coherently averaging the results for several random realizations of a layered poroelastic medium with given grain size and layer thickness distributions. The reflection loss predicted by this model was computed from the coherent component of the ensemble average of the reflected signal and it was found to be in good agreement with measured values by Nolle. The scattering strength was computed from the random component of the reflected signal, and its values were found to be in agreement with experimental data for mean grain sizes significantly less than the acoustic wavelength within the sediment. However, the simulated scattering strength dropped sharply below the observed values for grain sizes near or greater than the acoustic wavelength. This indicates that the model is only valid for incident waves that yield acoustic wavelengths near or greater than ten times the mean grain diameter of the sediment.

The approach that we have taken is based on sound physical principles. It is a significant extension of Biot's theory of acoustic propagation in porous media, and gives an insight to the processes that give rise to reflection and scattering from a granular medium such as water saturated sand, that is directly applicable to ocean sediments. The above agreement between model predictions and experimental measurement indicate that the approach is feasible. Follow on work will include computation of wave attenuation due to granularity, which would involve calculation of transmission coefficients through the granular material, and an attempt to derive an analytical model.

Papers[1,2] were presented at the Spring and Fall Meetings of the Acoustical Society of America, and an archival paper[3] has been submitted for publication in the Journal of the Acoustical Society of America.

Impact on S&T, or transition/integration expected:

The result will lead to a unified theory of propagation and scattering in porous media, applicable to ocean sediments over a broad range of frequencies, which will replace much of the disjointed collection of submodels currently in use, and which will properly explain the observed frequency, grain size, and grazing angle dependencies. After follow-on laboratory experimental verification, the results of this project will transition into sonar performance prediction models.

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1 Dennis Yelton and Nicholas P. Chotiros, New multiple scatter model of the ocean sediment. J. Acoust. Soc. Am. 97(5), Pt. 2, 3387, May 1995

2 Dennis Yelton and Morris Stern, A numerical investigation of the relative scattering of Biot fast and slow waves by a spherical inclusion in a poroelastic medium. J. Acoust. Soc. Am. 98(5) Pt. 2, 2972, November 1995

3 Dennis Yelton, Morris Stern, and Nicholas P. Chotiros, A model of acoustic scattering by granular, poroelastic ocean sediments, submitted for publication in J. Acoust. Soc. Am.

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To support research in understanding the mechanism of the wave attenuation and scattering in the porous media composed of granual material. The parameters to be controlled are sediment grain size, surface roughness, and gas content.

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